

Persorption of metallic iron particles

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Large, solid, undissolved food particles instantly enter the body from the intestinal lumen. We examined this phenomenon which we called 'persorption'. Such large particles are kneaded between the cells into the subepithelial region through the epithelial cell layer. Transport from the intestinal wall is via the portal system and by means of the chyle (Fig. 1). Starch granules with a diameter ranging from 5 to 100 μ were used as models for these experiments (Volkheimer, 1964, 1968; Volkheimer and Schulz, 1968; Volkheimer *et al*, 1968a, b, c, and d).

MATERIAL AND METHOD

Carbonyl iron powder¹ (particle size up to 8 μ) and Simetag iron powder² (particle size up to 62 μ) were used.

The iron powder was fed to dogs of average weight of approximately 17 kg.

Iron powder, 200 g or 250 g, was suspended in 500 g of cream and 250 g of milk and fed to the fasting dogs.

¹Mannesmann-Pulvermetall, Mönchengladbach, Germany.

²Badische Anilin- und Sodafabrik (BASF), Ludwigshafen/Rh., Germany.

Venous blood was drawn from a vein in a limb. Portal vein blood was obtained by drawing blood from the portal vein after barbiturate anaesthesia and laparotomy. The animals were then sacrificed by intravenous injections of barbiturate. Subsequently, bile was aspirated from the gall bladder and urine from the urinary bladder. (During the aspiration of bile and urine it is essential to keep these fluids in motion by repeated aspiration and reinjection. Otherwise the iron particles rapidly form a sediment.) Subsequently lymph was obtained by aspiration from the thoracic duct.

DEMONSTRATION OF IRON PARTICLES IN BODY FLUIDS The blood is haemolysed by the correct amount of an acetic acid water mixture (9:1). The lymph is diluted with water (1:20). The body fluids are centrifuged (15 minutes at 3,000 rpm). The sediments are then examined on a glass slide with a cover glass under a light microscope. The iron particles can be recognized by their ferromagnetic properties: they move if a magnet is brought close to them and thus it is possible to alter their position. With a microscope these movements can be observed if the magnet circumvents the slide.

The magnet used in these experiments was the perma-

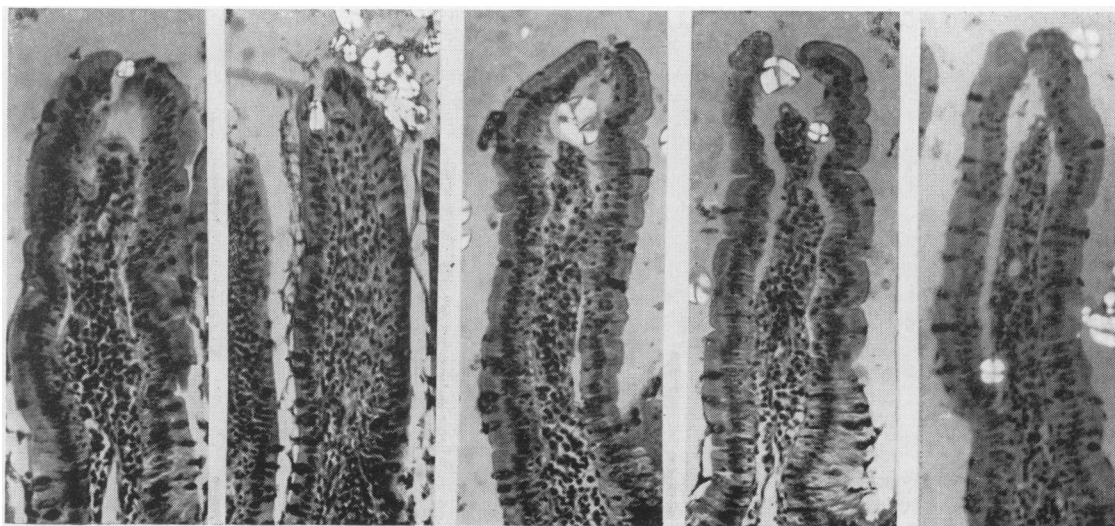


FIG. 1. Mechanism of persorption of starch granules demonstrated in the jejunum of rats.

nent magnet Oerstit 400.¹ As it is very small (4.5 mm diameter, 35 mm in length) it is possible to approach it closely to the slide. Frequently the iron particles in the sediment lie closely together and exercise group movements when the magnet is approached.

The identity of the iron particles found in the body fluids with the fed material was confirmed as well by x-ray structure analysis according to the method of Bebye-Scherrer.

RESULTS

With regard to site, intensity, and number of the interference rings the iron particles appeared identical with the original material administered with the food.

Twelve dogs were fed 200 g each of the two types of iron powder. Between 120 minutes and 180 minutes later several samples each of 10 ml of venous blood were obtained. The sediments of each 10 ml of the haemolysed blood showed from 28 to 133 iron particles which could be recognized by their ferromagnetic properties. After feeding 200 g of Simetag iron powder it was possible to find iron particles ranging in size up to 52 μ . No iron particles could be demonstrated in the blood in control tests.

Twelve fasting dogs were fed 200 g of Carbonyl iron powder suspended in cream and milk. Beforehand, as well as 10 minutes after the start of feeding and also at 30-minute intervals, 10 ml of venous blood was obtained by venepuncture. The iron particles in the blood sediments were counted as far as they could be identified by their ferromagnetic properties.

Three fasting dogs were fed 250 g of iron powder suspended in cream and milk. After 120 to 140 minutes the animals were sacrificed by intravenous injection of barbiturate. After thoracotomy 20 ml of chyle was aspirated from the thoracic duct. A sediment was obtained from this and the number of iron particles contained in the lymph sediment was determined. In the sediment of each 20 ml of chyle we found 35, 11, and 55 iron particles.

Nine dogs were fed 200 or 250 g each of iron powder. Portal vein blood was obtained at various intervals after laparotomy. Eight times we obtained lymph from the thoracic duct, nine times we obtained urine from the urinary bladder, and twice we obtained bile from the gall bladder by aspiration. The sediments of all body fluids mentioned showed iron particles which could be identified by their ferromagnetic properties. In control tests it was

¹DEW Magnetfabrik Dortmund/Germany.

never possible to demonstrate iron particles in the blood, bile, lymph, or urine.

COMMENT

Metallic iron particles with a diameter of up to 63 μ were fed to dogs in the form of iron powder. Numerous particles could be found in the venous blood, in the portal vein blood, in the lymph from the thoracic duct, in the bile, in the urine, and once also in the cerebrospinal fluid of the test animals. The particles could be identified in the sediments of these body fluids by their ferromagnetic properties.

On the basis of observations with other model particles (starch granules, polyvinyl chloride spherules) of the respective magnitude, it is possible to assume that uptake from the intestinal tract occurs by the persorption mechanism. This mechanism does not involve an active resorption process of the epithelial cell, but the large dimensional particles are 'kneaded' between the cells through the epithelial layer. Peristalsis of the intestinal wall plays an essential role in this process.

SUMMARY

Large particles of metallic iron ranging in diameter up to 52 μ can be demonstrated in the blood after they have been fed to dogs. These particles can be identified with the cylinder magnet on account of their ferromagnetic properties. Iron particles were also found in the urine, lymph, bile, and (once) in the cerebrospinal fluid.

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REFERENCES

- Volckheimer, G. (1964). Durchlässigkeit der Darmschleimhaut für grosskorpuskuläre Elemente (Herbst-Effekt). *Z. Gastroent.*, **2**, 57-64.
- , (1968). Das Phänomen der Persorption von Stärkekörnern. *Stärke*, **20**, 117-126.
- , and Schulz, F. H. (1968). The phenomenon of persorption. *Digestion*, **1**, 213-218.
- , —, Aurich, I., et al (1968a). Persorption of particles. *Ibid.*, **1**, 78-80.
- , —, Hofmann, I., et al (1968b). The effect of drugs on the rate of persorption. *Pharmacology*, **1**, 8-14.
- , —, Lehmann, et al (1968c). Primary portal transport of persorbed starch granules from the intestinal wall. *Med exp. (Basel)*, **18**, 103-108.
- , Wendlandt, H., Wagemann, W., et al (1968d). Beobachtungen zum Persorptions-Mechanismus. *Path. et Microbiol. (Basel)*, **31**, 51-58.